University of Toronto
Department of Statistical Sciences

STA261H1F LEC0101
Probability and Statistics II
Course Outline - Summer 2023

Lectures
TU 1:00 PM - 4:00 PM in MB128
TH 1:00 PM - 4:00 PM in MB128

Tutorials
TU 4:00 PM - 5:00 PM in MB128
TH 4:00 PM - 5:00 PM in MB128

Office Hours
MO 5:00 pm–6:00 pm (online)
WE 5:00 pm–6:00 pm (online)

Instructor: Luai Al Labadi

E-mail: luai.allabadi@utoronto.ca

Teaching Assistants: TBA

COURSE OVERVIEW

- **Course Description:** A rigorous introduction to the theory of statistical inference and to statistical practice. Statistical models, parameters, and samples. Estimators for parameters, sampling distributions for estimators, and the properties of consistency, bias, and variance. The likelihood function and the maximum likelihood estimator. Hypothesis tests and confidence regions. Examples illustrating statistical theory and its limitations. Introduction to the use of a computer environment for statistical analysis. (Note: STA261H1 does not count as a distribution requirement course).
- *Prerequisite:* STA257H1/ STAB52H3/ STA256H5
  Corequisite: MAT237Y1/MAT257Y1/MAT257Y5; MAT223H1/MAT224H1/ MAT240H1/MATA22H3/MATA23H3/MAT223H5/MAT240H5/MATB24H 3/MAT224H5
  Exclusion: ECO227Y1/ STA238H1/ STA248H1/ STAB57H3/ STA260H5/ ECO227Y5
- Pre-requisites are **strictly enforced by the department, not the instructor**. Students who do not meet the equivalent pre-requisites will be automatically dropped from the course.

- **Learning Outcomes:** By the end of this course, students should be able to:
  1. Recognize and compute the sampling distributions related to the normal distribution.
  2. Construct confidence intervals using the pivotal quantity method.
  3. Find different types of estimators for a parameter like the MLE and MME.
  4. Verify whether a given estimator is unbiased, consistent, and efficient.
  5. Find a complete and sufficient statistic for a parameter.
  6. Construct UMVUE for a certain parameter.
  7. Construct the most powerful test and the likelihood ratio test.
  8. Construct the least squares estimates for linear statistical models and examine some of its properties.

COURSE MATERIALS

- **Course Content:** All lecture slides, materials, and important announcements will be posted on Quercus https://q.utoronto.ca**.** Please make sure to check it regularly so you don't miss anything.

- **Required Textbook:** Mathematical Statistics with Applications by Wackerly, Mendenhall and Scheaffer, 7th edition. ISBN-13: 978-0-495-11081-1

- **Additional References:**
  - Introduction to Probability and Mathematical Statistics by Bain and Engelhardt, 2nd edition.
  - Introduction to Mathematical Statistics by Hogg, McKean and Craig, 8th edition.
  - Mathematical Statistics and Data Analysis by Rice, 3rd edition.

- **Calculators:** Handheld, non-programmable calculators may be used during quizzes and tests. Any calculator that has a logarithm, square root, and one memory button will suffice for this course, so there is no need to buy an expensive calculator.

- **Statistical Computing:**
  - This course uses the statistical package R/RStudio/Jupyterhub.
  - R is free statistical software and it can be downloaded from http//cran.r-project.org/.
  - Jupyterhub (https://jupyter.utoronto.ca/) allows you to work with this software without having to download anything to your computer.

COURSE COMPONENTS

- **Lectures:** Attending lectures, actively engaging with the topics, and seeking clarity on any questions are crucial aspects of succeeding in this advanced-level course. To effectively learn the material, students should make the most of the lecture time and regularly practice the concepts covered. Relying on last-minute cramming before tests/exams is unlikely to be beneficial.

- **Tutorials:** The first tutorial session is scheduled for Thursday, July 6th, and will be conducted by your Teaching Assistant. The suggested problems listed in the syllabus are ideal for preparing for the tutorial discussions. Attending tutorials is highly beneficial for students as they provide an opportunity to gain a better understanding of the course material, especially when it comes to problem-solving.

- **Office Hours:** The instructor will hold office hours through Zoom. The link will be posted on Quercus. It is recommended that you visit office hours whenever you have a question about the material. It is very important to have material clarified as quickly as possible. Don't wait until the last minute to ask your questions.

- **Piazza:** This is for student-led discussion. All questions about course material should be posted here or asked during instructor/TAs office hours. The instructor and TAs will monitor the board and will help answer questions, but students are encouraged to answer posts and help their fellow classmates.

ASSESSMENTS AND DEADLINES

Type	Due Date	Room	Weight
Test 1	July 18	TBA	25%
Test 2	August 3	TBA	25%
Final	TBA	TBA	50%

- **Term Tests Policies**
  - All the term tests start at 3:30 pm and end at 5:00 pm on the dates specified above.
  - There will be class from 1:00-3:00 on the day of term test.
  - Your test may be in a different room. The location will be communicated on Quercus.
  - Missed Term Work:
    - ✓ If you are unable to attend a test due to a valid reason, please send an email to Luai in advance, if possible. Additionally, it is important to declare your absence on ACORN.

- ✓ If you missed one term test, no makeup will be given for the missed term test. The mark of the missed term test will be substituted based on the final exam.
- ✓ If both tests are missed, a makeup test will be held on Thursday, August 10 from 5:10 to 6:40. More information will be provided on Quercus. The makeup test will cover all course material and count for 25% of the final grade. Any unallocated weight from the missed tests will be shifted to the Final exam. **Not attending the makeup test will result in a mark of zero for that test. In this situation, the final exam will account for 75% of the overall grade.**

- **Final Exam**
  - Final exam is scheduled during the August examination period by the Office of Registrar. The final exam will cover the entire course. Final exam grades will not be posted in Quercus. Issues related to final exams (e.g. time conflict, remark requests/exam viewing) should be addressed to the Registrar's office. See
    - https://www.artsci.utoronto.ca/current/faculty-registrar/exams-assessments/exam-conflicts
    - https://www.artsci.utoronto.ca/current/faculty-registrar/exams-assessments/exam-viewing
  - *Missed Final Exam:* Students who cannot complete their final examination due to illness or other serious causes must file an online petition: https://www.artsci.utoronto.ca/current/faculty-registrar/petitions/deferred-exam. Students must also record their absence on ACORN on the day of the missed exam or by the day after at the latest. Please refer to https://www.artsci.utoronto.ca/current/faculty-registrar/petitions/deferred-exams for more information on how to request a deferred exam, and deadlines.

EMAIL POLICY

Your email must originate from your University of Toronto email account when you contact your instructor by email. The subject line should contain the course number and a relevant subject (indicating what the email is about). Be sure to include your full name and student ID number in the body of the message. Before you send an email, make sure that you are not asking for information that is already available from the course outline/website/announcements, or questions about the course material that are more appropriate for discussing during office hours or discussion board on Piazza. **In general, your instructor and TAs will not answer technical questions about the course material by email**.

INTELLECTUAL PROPERTY

Course materials provided on Quercus, such as lecture slides, assignments, tests and solutions are the intellectual property of your instructor and are for the use of students currently enrolled in this course only. Providing course materials to any person or company outside of the course is unauthorized use. This includes providing materials to predatory tutoring companies.

ACADEMIC INTEGRITY

The University treats cases of plagiarism and cheating very seriously. It is the students' responsibility for knowing the content of the University of Toronto's Code of Behaviour on Academic Matters. All suspected cases of academic dishonesty will be investigated following procedures outlined in the above document. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see http://academicintegrity.utoronto.ca/). Offences include, but are not limited to:

On tests and exams:

1. Using or possessing unauthorized aids.
2. Looking at someone else's answers during an exam or test.
3. Obtaining or providing unauthorized assistance.
4. Misrepresenting your identity.

In academic work:

1. Falsifying institutional documents or grades.
2. Falsifying or altering any documentation required.

ACCESSIBILITY NEED

The University of Toronto offers academic accommodation for students with disabilities. If you require accommodations, or have any accessibility concerns about the course, the classroom, or course materials, please contact Accessibility Services as soon as possible: accessibility.services@utoronto.ca or http://accessibility.utoronto.ca.

COURSE TOPICS

Sampling Distributions and the Central Limit Theorem - Chapter 7	
7.1	*Introduction*
7.2	*Sampling Distributions Related to the Normal Distribution*
7.3	*The Central Limit Theorem*
7.5	*The Normal Approximation to the Binomial Distribution*
Estimation - Chapter 8	
8.1	*Introduction*
8.2	*The Bias and Mean Square Error of Point Estimators*
8.3	*Some Common Unbiased Point Estimators*
8.4	*Evaluating the Goodness of a Point Estimator*
8.5	*Confidence Intervals*
8.6	*Large-Sample Confidence Intervals*
8.8	*Small-Sample Confidence Intervals for μ and $\mu_2 - \mu_1$*
8.9	*Confidence Intervals for σ^2*
Properties of Point Estimators and Methods of Estimation - Chapter 9	
9.1	*Introduction*
9.2	*Relative Efficiency*
9.3	*Consistency*
9.4	*Sufficiency*
-	*Completeness [Exercise 9.68; extra notes will be provided]*
9.5	*The Rao-Blackwell Theorem and Minimum Variance Unbiased Estimation*
-	*Cramer-Rao Inequality [Exercise 9.8; extra notes will be provided]*
-	*Exponential Family [Exercises 9.45-9.48; extra notes will be provided]*
9.6	*The Method of Moments*
9.7	*The Method of Maximum Likelihood*
Hypothesis Testing - Chapter 10	
10.1	*Introduction*
10.2	*Elements of a Statistical Test*
10.10	*Power of Tests and the Neyman-Pearson Lemma*
10.11	*Likelihood Ratio Tests*
Linear Models and Estimation by Least Squares - Chapter 11	
11.1	*Introduction*
11.2	*Linear Statistical Models*
11.3	*The Method of Least Squares*
11.4	*Properties of the Least-Squares Estimators: Simple Linear Regression*

SUGGESTED PROBLEMS FROM THE TEXTBOOK

They will form the basis for the term tests and the final exam, although it does not imply that you will be tested on these problems. They will be essential for your understanding of the topics covered in class. In addition, some of them will be discussed during tutorials.

- *Section 7.2*
  Exercises: 7.9, 7.11, 7.15, 7.19, 7.20, 7.21, 7.29, 7.30, 7.34a, 7.36, 7.37, 7.38.

- *Section 7.3*
  Exercises: 7.43, 7.49, 7.57, 7.58.

- *Section 7.5*
  Exercises: 7.73, 7.77, 7.79, 7.81, 7.84, 7.87.

- *Supplementary Exercises: 7.95, 7.96, 7.97.*

- *Section 8.2*
  Exercises: 8.1, 8.2, 8.3, 8.5, 8.8, 8.9, 8.12, 8.13, 8.14, 8.15, 8.19.

- *Section 8.4*
  Exercises: 8.27a & b, 8.29.

- *Section 8.5*
  Exercises: 8.39, 8.41, 8.43, 8.44, 8.46, 8.47, 8.48.

- *Section 8.6*
  Exercises: 8.57, 8.58, 8.59, 8.61.

- *Section 8.8*
  Exercises: 8.83, 8.85, 8.92.

- *Section 8.9*
  Exercises: 8.95, 8.97, 8.98, 8.99.

- *Supplementary Exercises: 8.125, 8.128, 8.129, 8.133.*

- *Section 9.2*
  Exercises: 9.1, 9.3, 9.4, 9.5, 9.7.

- *Section 9.3*
  Exercises: 9.15, 9.16, 9.17, 9.19, 9.20, 9.24, 9.30, 9.32, 9.34, 9.35.

- *Section 9.4*
  Exercises: 9.37, 9.38, 9.39, 9.43, 9.45, 9.46, 9.49, 9.50, 9.51, 9.52, 9.53, 9.54.

- *Section 9.5*
  Example 9.6, Example 9.7, Example 9.9.
  Exercises: 9.59, 9.60, 9.61, 9.62, 9.63.

- *Section 9.6*
  Example 9.11 and Example 9.12.
  Exercises 9.69, 9.70, 9.71, 9.72, 9.75, 9.77, 9.78.

- *Section 9.7*
  Example 9.15, Example 9.16, Example 9.17.
  Exercises 9.80, 9.81, 9.83, 9.85 a-d, 9.87, 9.88, 9.93a, 9.97.

- *Supplementary Exercises: 9.104, 9.106, 9.107.*

- *Section 10.2*
  Exercises: 10.3, 10.6.

- *Section 10.10*
  Example 10.22, Example 10.23.
  Exercises 10.89, 10.91a & b, 10.95, 10.96b, 10.99, 10.101.

- *Section 10.11*
  Example 10.24, Example 10.25.
  Exercises: 10.105, 10.107, 10.113.

- *Section 11.3*
  Exercises: 11.1, 11.4, 11.10, 11.11.

- *Section 11.4*
  Exercises: 11.15, 11.20, 11.21, 11.22.

TENTATIVE COURSE SCHEDULE

Date	***Topics***
Week 1	*7.1, 7.2, 7.3, 7.5*
Week 2	*8.2, 8.3, 8.4, 8.5, 8.6*
Week 3	*8.8, 8.9, 9.1, 9.2, 9.3, 9.4, Completeness, 9.5*
Week 4	*9.6, 9.7, Cramer-Rao Inequality, Exponential Family*
Week 5	*10.1, 10.2*
Week 6	*11.1,11.2, 11.3, 11.4*